

Private-public partnerships for expanding broadband access: lessons from the digital ring in Ceará, Brazil

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Abstract

The Cinturão Digital do Ceará (CDC) is a pioneering infrastructure project that delivers broadband access to large cities, small towns and rural areas throughout the State of Ceará in northeast Brazil. The CDC was built and operated using a unique business model that innovates on the standard public-private partnership (PPP) an increasingly popular means to undertake Information Communications Technology (ICT) deployments. We review the technical, legal and organizational features of the CDC project with a focus on how they were designed to cope with the unique economic and political conditions of the region. It is particularly instructive how the CDC business model evolved over time in response to political challenges and market failures. We highlight how the model can be adapted to other regions within Brazil, as well as to other developing countries, that seek to pursue dual goals of financial sustainability expansion of broadband access to underserved populations.

Introduction

Despite evidence that fast, affordable digital infrastructure contributes to economic development and social inclusion, the economic realities of broadband projects can limit their deployment. The high cost of reaching remote communities and the paltry revenues

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from low-income inhabitants often make these projects unprofitable. Publicly-owned broadband networks have been built where for-profit alternatives are lacking. In other cases public-private collaborations have been formed with the goal of meeting these needs by capturing the benefits of both public and private ownership. A unique collaboration of public and private interests was at the heart of the Ceará Digital Beltway (Cinturão Digital do Ceará, CDC) project that is the subject of this paper. The CDC is a fiber network with WiMAX wireless extensions that delivers high-speed data transmission throughout the Brazilian state of Ceará. This project was undertaken by the State of Ceará ICT company Empresa de Tecnologia da Informação do Ceará (ETICE) which specified the terms and conditions for collaboration with other public and private sector partners. The CDC model innovates on the more conventional model of a public-private partnership (PPP) to accommodate the economic and political conditions that prevail in the target markets.

This paper examines the history and economics of the CDC in the broader context of Internet development in Brazil. We will show how the State of Ceará met its broadband needs by innovating on the conventional PPP model responding to the local market conditions and political vagaries. It was able to combine public financing and ownership with the powerful incentives of private enterprise to bring high-speed data services to underserved areas. Importantly, over time, ETICE has adapted its model by listening to its constituents and partners and responding to market conditions,. Finally, we address whether the unique CDC business model could provide an effective solution to the deployment of broadband services in other parts of Brazil and the developing world.

But first, we present a brief overview of the evolution of the Internet in Brazil, including Brazilian policies for broadband expansion, to provide some context for the subsequent discussion on the CDC.

The evolution of the Internet in Brazil

Beginning in the late 1980s, and inspired by the development of the Internet in the United States and Europe and contacts with some of its early pioneers, Brazilian academic researchers laid the groundwork for connecting local networks to the global Internet. Together with government supporters, they launched the National Research Network, now National Education and Research Network (RNP), modeled after NSFNet in the United States. The RNP was first connected to the global Internet during the United Nations Conference on the Environment and Development in May 1992. The link was made by the federal state telecommunications company, Embratel. In that year the RNP connected eleven Brazilian cities at speeds of 64 Kbps or 9.6 Kbps.

Commercial use of the Internet in Brazil began only in 1995, with Embratel providing the backbone and a multitude of small Internet Service Providers (ISPs) providing Internet access to customers. To this day small and medium ISPs play an important role in the expansion of the Brazilian Internet. Also in 1995, the Brazilian Internet Steering Committee (CGR.br), a multi-stakeholder body performing functions similar to ICANN (established only in 1998) was launched. The privatization of Brazilian telecommunications took place in 1998, leading to a rapid expansion of the commercial Internet supervised by CGI.br. Backbone services were provided by commercial carriers that gave priority to major urban centers, especially their higher-income areas. The small and medium ISPs pioneered service

in less attractive markets, but relied on the four major telcos for access to the Internet (Knight, 2014).

By 2013 fixed broadband connections (defined as 64 Kbps or greater) totaled 13.2 million providing 39% of households across Brazil's 5,570 municipalities with this kind of connectivity. Third generation (3G) wireless connectivity has been growing fast, covering 3,564 or 64% of Brazilian municipalities by the end of 2013. Fourth generation (4G) service is now being rolled out in major urban areas. Mobile broadband (3G and 4G) penetration was 35% at the end of 2013, much lower than most developed countries, but growing rapidly. Digital inclusion of individuals (defined as access to the Internet in the three months prior to surveys) reached 51% in 2013, but remains much lower in rural areas at 21%. There is also a large gap in Internet use between the richest segment of the population (Class A, at a 97% rate) and the poorest segments (Classes D and E, at just 17%) (Cetic, 2014). In general, broadband service in Brazil remains slow, expensive, and often unreliable (Knight, 2014).

The State of Ceará

The State of Ceará is located in the relatively poor Northeast region of Brazil. The state's patterns of Internet service and use are similar to those in the rest of Brazil, with deficiencies in service availability and quality, as well as gaps between urban and rural areas and across socioeconomic groups. As with other Brazilian capital cities, Ceará's capital, Fortaleza, has better Internet connectivity than anywhere else in the state. This is especially true for academic and state institutions which have access to Gigafor – the RNP metropolitan network that has been expanded in partnership with ETICE, the state ICT company, and now forms part of the CDC. Forty-three percent of Ceará's population of 8.7 million resides in Fortaleza, and Fortaleza's relatively wealthier population is better connected to the Internet: 43% of households in Fortaleza have at least one computer with an Internet connection (IBGE, 2014).

Small towns and rural areas do not have the same kind of Internet service availability, quality, and cost as Fortaleza and smaller cities. We estimate that less than 20% of rural homes in Ceará have an Internet connection (IBGE, 2014). The discrepancy between urban and rural areas persists despite the advances brought to the interior by the CDC project. As is typical throughout Brazil, Internet connectivity in the poorer areas of the state is often supplied by small and medium ISPs.

Brazilian policies for broadband expansion

The basic regulatory framework which until today governs the Brazilian telecommunications industry is the General Telecommunications Law of 1997. This law also created the National Telecommunications Agency (Anatel) that is charged with defending the interests of the State and citizens, encouraging competition, universalizing telecommunications services, and modernizing telecommunications infrastructure. But it was only in 2010 that the Brazilian Federal Government launched the National Broadband Program (Plano Nacional de Banda Larga – PNBL), to address the problems noted above. The principal instrument for achieving these objectives is Telebras, a federal telecommunications holding company that was put into a state of hibernation during the telecoms privatization period and was re-activated as an operating company for this purpose.

Funding of Telebras to achieve PNBL objectives has been very limited, due to competing demands on limit federal budgets. However some progress has been made in creating a national backbone through public-public partnerships with public electric distribution companies, the state petroleum company Petrobras, and to a lesser extent with private telcos that lease dark fiber on their backbones. Telebras also provides backbone services for small and medium ISPs at below-market prices in return for their making basic (1 Mbps) service available at a low cost of R\$29 (about US\$12 per month at current exchange rates), which in some states is reduced by an exemption on value added taxes on telecommunications services.

At the same time, the RNP has been expanding and upgrading to gigabit speeds both its inter-urban backbone and metropolitan networks serving research and higher education institutions. By 2014 RNP had points-of-presence (POPs) in all 26 states and the Federal District, of which 24 had connections of over 1 Gbps (RNP, 2014). In 2007 RNP launched a program to create metropolitan networks in state capitals and other major cities. By October 2014, RNP had built 39 such networks and another 5 were under construction. This has been accomplished by innovative partnerships with state and municipal governments, electric power distribution companies, urban subways and toll roads, and, since 2011, with Telebras. These partnerships involve trading rights of way, ducts, poles, fiber and other infrastructure in return for excess dark fiber. As mentioned above, Fortaleza is served by such a metropolitan network called Gigafor.

The newest development involving RNP is a program called Veredas Novas (New Paths) to bring high-speed broadband to research and higher education institutions outside the capitals of the 26 Brazilian states. This is a joint program of the Ministry of Education, Ministry of Telecommunications, and Ministry of Science, Technology and Innovation. Ceará, through its state ICT company, ETICE, participates in both Gigafor and Veredas Novas.

The CDC as a PPP

The concept of a public-private partnership encompasses a wide variety of collaborations between government and private firms. The typical PPP, if there is one, specifies private ownership of infrastructure that is usually built by a private entity and then eventually transferred to the government agency that authorized the construction. At one extreme, a private entity undertakes all stages of infrastructure deployment by designing, building, financing and operating the facility (IMF, 2012).

The CDC departs from this norm in a number of ways. To begin with, the government of Ceará designed, built, and financed the CDC fiber network. Those tasks, usually delegated to one or more private companies, were retained by the government. Nevertheless, the International Monetary Fund (IMF) takes a more flexible definition of a PPP, treating private sector operation of a government-owned asset as a PPP ¹. For this reason, and because a collaboration between the government and private operators lies at the heart of the CDC project, we refer to it as a PPP.

¹That arrangement has been classified as an *operating leasing*. When the private entity is responsible for maintenance and improvement as well, which is the case with the CDC, it is described as a concession even if the entity does not necessarily sell services directly to the public (IMF, 2012), p.7.

The first application of Brazil's PPP law of 2004 was the Number 4 Metro line in the city of São Paulo (Delmon, 2010). This extension to the existing subway routes was built by the State of São Paulo with funding from Inter-American Development Bank and several major international banks. As with the CDC, the design, build and finance phases were all undertaken by government agencies. A consortium of private firms operated the line with transit fares as their principal source of revenue.

Subsequent projects in Brazil adopted some form of public-private partnership, including one notable ICT project – the data center built for use by the Banco do Brasil and Caixa Econômica Federal in Brazil's capital, Brasília (BB, 2014). The CDC is the first communications network that was created in Brazil using a PPP model, though it is strictly speaking a concession rather than a PPP under the specific federal and Ceará state laws. Brazil enacted a federal PPP law in December 2004 (Planalto, 2004), and the state of Ceará enacted its own law the same day (BNB, 2004). For a review of Brazilian PPP experience, see (Cesar Queiroz & Serebrisky, 2014).

The earliest examples of a PPP formed in developed countries, and those focused on transportation and utilities infrastructure. In time, the use of the arrangement spread to other markets and other services – spurred by the exigencies of the global recession.

An arrangement that shares several of the CDC's distinct features is the SuperNet in Alberta, Canada (Arnaud & Macneil, 2001). That broadband network consists of over 13,000 kilometers of trenched fiber optic cables and 2,000 kilometers of high-speed wireless links. Bell Canada owns and operates a portion of the network that connects 27 cities in Alberta. The provincial government owns the remainder of the network that connects 402 communities in rural areas (Supernet, 2004). The Alberta SuperNet is what sometimes is called condominium dark fiber network since the occupants of the fiber network hold the equivalent of indefeasible rights of use (IRU) to a portion of the bandwidth (Arnaud & Macneil, 2001).

Basic Economics of an ICT PPP

Any one of the various flavors of a public-private partnership constitutes an attempt to capture the benefits of the two forms of ownership while escaping their respective disadvantages. In this section we briefly identify characteristics of a PPP that affect its likely success or failure. The resulting pros and cons of PPP design are then used to evaluate the arrangement that was ultimately used in the case of the CDC.

Any infrastructure project requires the completion of a sequence of tasks (i.e., design, construction, financing, operation, maintenance and modernization), each of which could be carried out by the government or a private entity. An important issue when organizing a PPP is whether to bundle those tasks to be taken on by a single private firm, or to unbundle them so as to allow multiple contractors. As mentioned, ETICE designed, built and financed the CDC, whereas private interests are contracted to operate, maintain and modernize the original fiber network.

When contracting to complete the tasks, various criteria should be considered. Presumably the government's goal in forming a PPP is maximization of social welfare which subsumes cost and production efficiency. In so doing, however, it must respect the private market incentives that bear on the potential contractors. Indeed, the rationale for the CDC was a market failure that resulted in too little profit to justify a private investment to cap-

ture the net social benefits. The CDC had as secondary goals the promotion of competition in the data transmission market, under the assumption this would further the primary goal of benefiting the rural user population, and second, covering ETICEs own operations and maintenance costs for the CDC network.

Many considerations arise when deciding on how to structure the PPP arrangement. First, what are the relative capabilities of the public and private parties in terms of technical know-how, construction and operation expertise, and financial access? Second, how able are the parties to cope with the various sources of risk, i.e., operational, competitive, political, and regulatory risks? Third, are there positive or negative externalities that arise between successive tasks that could be realized by bundling the tasks? Fourth, how should the public and private partners share in operating cost reductions resulting from technological change? (Iossa & Martimort, 2014).

While ETICE built the CDC to address the absence of private investment in broadband infrastructure and to reduce the cost of its own data transmission requirements, it recognized the powerful incentives of private partners to find cost efficiencies and to innovate on digital services. In particular, ETICE took advantage of such incentives through use of an auction mechanism to engage private interests. Proper design of a PPPs procurement mechanism helps allocate the fiber capacity to providers of end-user services that are most efficient and innovative relative to market alternatives.

Although ETICE sought to compensate for what it saw as a market failure, it also recognized that governments are prone to failures as well. Arguably the most important weakness of government participation in a PPP is that governments lack strong economic incentives when making economic decisions. The government party cannot help but respond to political and electoral pressures, and it is bound by administrative law and bureaucratic practice. Current authorization and funding may extend no further than the next state or federal elections. Some of institutions may severely limit the governments range of action as when laws demand that equipment be domestically manufactured.

Regardless of its range of freedom, the government partner can be an obstacle to the PPPs success. Weak administrative laws and minimal oversight can create a possibility that the government partner will be captured by private interests. Especially for projects that extend over many years, where the government must work closely and continuously with the private partners, there is a tendency to show favoritism that could be incompatible with the original social goals of the project.

While it may be disadvantaged in pursuit of efficiency, governments have unique advantages that they can contribute to the partnership. Prominent among these is its pursuit of an equitable allocation that is not achievable from the market outcome. Another is curbing the market power of monopolies and oligopolies in the provision of telecommunications services. A further advantage is the ability to establish long term plans and coordinate different actors (public, private, academic) involved in a complex program such as the CDC. The CDC was seen as the only means to bring the digital age to an underserved and unserved segments of Cearás population. Governments can not only build a facility such as the CDC, they can also use direct means to ensure the services are available to this population (e.g., rules on nondiscriminatory prices or subsidies), or they can work indirectly to increase competition in the downstream markets (e.g., lowering entry costs or providing competition to for-profit entities).

In addition, governments can use their fiscal powers to obtain financing at a lower rate than private participants. Similarly, governments often can use their control of the legal system and regulatory policy to divert resources to the benefit of households and businesses located in these remote areas. The public ordering can be used to ensure contracting that supports investment by mitigating incentives for hold up and avoid the costly possibilities of renegotiation.

These are fundamental considerations in the analysis of the CDC experience. In the next sections, we describe the Development of the CDC and the recent challenges in implementing the CDC public-private partnership.

History of Etice and the CDC Network

The CDC is a pioneering project in Brazil to promote statewide connectivity and digital inclusion, and is considered Ceará's highest profile ICT initiative. The CDC is Brazil's largest and fastest public broadband network, accessing nearly 80 percent of the urban population of the state. Today the CDC covers nearly 100 or the state's 184 municipalities.

This section discusses the context and business model for the initial development of the Cinturão Digital do Ceará network, describes the current network infrastructure, and discusses the results and achievements of the CDC thus far.

Background on ETICE

The CDC was developed by ETICE, the state of Ceará Information Technology Company. ETICE was created in 2001, with the closure of its predecessor, SEPROCE, the state data processing company. ETICE was established as an autonomous public company linked to the Ceará State Planning and Management Secretariat (SEPLAG) with the government being the sole shareholder. Between 2001 and 2007, when a new state administration took office, ETICE's main function was to provide specialized IT staff to state government agencies, including the executive, legislative and judiciary branches.

Starting in 2007 ETICE took on a much broader role, becoming responsible for both ICT services and strategic planning for the state of Ceará, with its president acting as a de facto state Chief Information Officer (CIO). The company has control of its own assets, and benefits from administrative, financial and technical autonomy in its activities. Since 2007, ETICE has been led by Dr. Fernando Carvalho, a professor of Computer Science at the Federal University of Ceará and one of the authors of this paper. Dr. Carvalho leads an experienced team of IT and telecommunication professionals. Under his leadership, ETICE has developed several important projects to enhance the ICT capabilities of the state, including the development of the CDC broadband network and the modernization of the State of Ceará Data Center, among other projects.

CDC Objectives

When a new state government took office in 2007, a plan was developed to build a modern telecommunications infrastructure in Ceará. The central idea was to build a fiber optic network that reached all areas of the state and to provide ETICE with the human and financial resources to operate this network.

The CDC project had two principal objectives. The first objective was to carry out public investments in order to decrease the state operating expenditures on connectivity services. At the time, the state was paying high rates to a regional, monopolistic operator, totaling \$29 million per year, for the use of an obsolete network that was built to support fixed line telephony. ETICEs initial investment in the CDC was R\$68 million, including the deployment of fiber and equipment. The goal was to recover this investment by reducing the telecommunications costs of the government, especially in towns with more than 50,000 inhabitants. Today, the operational cost of the network is only R\$7 million per year, with significantly improved quality. Although the network covers 80% of the municipalities in the state, another R\$8 million per year is paid in fees to reach areas without CDC coverage. But overall, the CDC has decreased annual telecommunications costs by 48% for the state of Ceará.

The second principal objective of the CDC was to provide universal broadband coverage throughout Ceará, and particularly in smaller towns and rural areas. Today, public entities, including municipal governments, are served with high-speed connectivity and pay a monthly rate based on their amount of inbound and outbound traffic. Public schools, customs offices, hospitals, police stations and many types of public services run their applications through this infrastructure. These applications include services such as telemedicine, distance education, security camera networks, remote scanners for cargoes, and remote management of transportation infrastructure. The network also supports the management capacity of government agencies in the state.

The CDC Business Model

The CDC aims to reach long-term financial sustainability using a business model that includes (a) usage-based fees for state government clients, (b) sale of network services to municipalities and local populations at cost, and (c) leasing network capacity to private sector concessionaires to cover ETICEs operational costs and maintenance expenses of the CDC network.

All state government organizations including schools, hospitals, public service agencies and many others are now connected to the CDC. There are more than 250 broadband contracts, with Internet connectivity of up to 1 Gbps linking more than 2,000 points throughout the state, with 1.5 million users. Monthly fees are based on usage. For each Gigabyte downloaded, ETICE charges R\$7.10 per month (about US\$ 3 at the current exchange rate). This monthly fee helps to cover the operational costs of the installed network, including an overhead of about 15%. It is important to note that any user wanting to expand the fiber optic network can deploy new cable, provided these conform to ETICEs technical standards. When the cable becomes operational, the user begins receiving services from ETICE. Today, the network initiated by ETICE has been expanded by about 25% through this type of arrangement.

Municipalities also participate in the CDC through public requests for proposal (RFPs) to receive, at cost, the transfer of data from Fortaleza. Forty-five municipalities currently participate. It is important to note that, prior to the CDC, the cost of Internet in the interior of the state was very high, given the scarcity of fiber connections. (Prior to the CDC, municipal contracts with providers ranged from R\$9,000-R\$16,000 for 5 full Mbps; today the CDC delivers 200 full Mbps for R\$4,000.) With this initiative, municipalities ob-

tain access to the Internet at a cost reduction of more than 90%, considering the price per Mbps. Each municipality hires ISPs to deliver Internet access in Fortaleza, at the ETICE headquarters. ETICE then provides transport at up to 200 mbps to the municipality which then distributes this bandwidth locally through local ISPs. As the municipal governments on average need only 20 Mbps, local ISPs distribute the excess bandwidth (about 180 Mbps) in services to the population. ETICE plans to expand this type of initiative, which supports municipal governments, ISPs in Fortaleza, and local ISP firms at the municipal level. The model also provides local citizens with high-quality broadband at attractive prices, utilizing the excess capacity of the network.

The academic community has also played a role in the development of the CDC. Before the launch of the CDC, a proof of concept was conducted to validate the operational and economic viability of the project. At the beginning of 2007, the RNP built a fiber optic ring with 18 pairs of fiber in Fortaleza to connect universities and research centers in the metropolitan area. However this infrastructure was not operational because there was no maintenance contract for the network. In exchange for the use of two pairs of fiber for state administration, ETICE proposed to maintain the network, through an outsourcing contract. Subsequently, ETICE utilized these two pairs of fiber to connect 42 public institutions in Fortaleza through its own network, utilizing Metro-Gigabit Ethernet. ETICE invested R\$1.1 million (about US\$460,000 at the current the exchange rate), including equipment and additional fiber, with a network speed of 60 Mbps for each point. This resulted in ETICE recovering its investment costs in only 90 days. After the CDC was deployed, the cooperation with RNP was extended to include the entire state of Ceará. RNP now deploys necessary fiber to expand its network, and ETICE manages the network, which currently reaches 45 universities and research institutions in the state connected through a 1Gbps Metro-Ethernet. This experience with RNP served to validate the technology, and provide a template for subsequent agreements with private sector partners.

A similar swap arrangement was utilized in the initial development of the CDC. Through a partnership with the private energy utility company Enel, that owns the state electrical utility company COELCE, ETICE was able to deploy the backbone network at significantly lower capital outlay than would a purely private network. ETICE signed a contract to use COELCEs electrical poles and substations and, as compensation for this access, the power company gained the right to use two pairs of fiber in the CDC network. Later, the same formula was extended to all fiber deployed through COELCEs poles and towers. Today COELCE utilizes this fiber to control its stations and to expand its smart grid. This cooperation with COELCE enabled a significant reduction in the cost of broadband for ETICEs customers in the state.

Other private firms are increasingly involved in the use and maintenance of the backbone network. ETICE has negotiated access to the network for a variety of private firms, and retains 8 to 10 fiber pairs, each with a 10 Gigabit transfer capacity available for sharing with companies in future public-private partnerships. During the second phase of the project, to be discussed in more detail further below, part of the network capacity will be leased under concession agreements to private sector operators. These operators will provide connectivity, value added services, and expand the network based on their own business objectives. In parallel, during the second phase, the State of Ceará will expand the CDC network to new areas of the state, and particularly to areas where private sector operators

lack financial incentives to provide connectivity services. Hence, Phase II of the CDC will utilize a hybrid business model, combining the profit incentives of the private sector with the public sector mission to provide universal broadband access in the state.

The public-private model has been well received across industry segments. The state-provided network reduces capital outlays for private firms seeking to expand their services throughout the state. Interested stakeholders include large telcos, ISPs, cable television companies, fiber-to-home providers and rural telephony providers. Through this public-private approach, ETICE seeks to ensure that its investments stimulate private ICT industry development while lowering costs for delivery of public services.

CDC Deployment and Technology

By May 2008, after the proof of concept with RNP and the swap agreement with COELCE, ETICE began development of the CDC network. ETICE conducted a public bid for the deployment of the fiber optic network, won by Schahin Engenharia. The process was temporarily halted when the company that came in second contested the bid in the Brazilian courts. After a delay of several months, Schahin was confirmed as the winning bidder based on technical capability and cost, and the construction of the network began in January 2009. There was a great deal of effort to recover the lost time, and the network was completed in September 2010, on time and on budget. In 2011, the State of Ceará passed Law 15,018, which designated ETICE as the manager of the CDC.

The CDC initially included about 3,000 kilometers of fiber optic cables connecting the 50 most populous cities in the state. This connectivity was augmented by high-capacity wireless WiMAX (IEEE 802.16) radios for delivery of broadband connections beyond the reach of the fiber optics cables, and lower capacity Wi-Fi radios for delivering localized connectivity, including free community Wi-Fi in the central plazas of several cities in the state.

The network consists of 24 fibers in the main ring, and 24 or 12 fibers in linear extensions (12 fiber extensions cover smaller cities), as well as last mile deployments. These main ring, extensions, and last mile cables contain dark fibers (not used), which will be leased to private operators, as discussed further below.

The service provided by ETICE is based on the technology Ethernet over DWDM (Dense Wavelength Multiplexing) technology, see (Saengudomlert & Gallager, 2006). There are 65 stations separated by an average of 40 kilometers. These stations regenerate the signal and have IP switches. The stations are strategically located in proximity to the 50 largest cities and towns in the state, and the optical ring provides redundancy for the network. The installed capacity is 20 Gbps between stations.

In densely populated urban areas, Metro-Ethernet technology is used, with speeds of 1 and 10 Gbps. In the capital Fortaleza, a GPON (Gigabit Passive Optical Network) network is used for 811 subscriber points, including schools. It is worth noting that in 55 municipalities there are towers with point-multipoint radio, using WiMAX (IEEE 802.16) in the 3.5 and 4.9 Ghz frequencies, with the latter being used only for public safety and rescue services. All the Personal Mobile Radio (PMR) services of the state police utilize the fiber optic infrastructure of the CDC, through the technology Terrestrial Trunked Radio (TETRAPOL) over IP. Five thousand portable and vehicle-based terminals have been installed in the TETRAPOL network.



Figure 1. CDC state network

Operational Learned Lessons

After four years of operation, ETICE has learned a number of valuable operational lessons that are applicable for similar projects in other regions. We will briefly address three challenges: dealing with vandalism and theft, SLAs for outsourced managed services, and preventing overheating.

Vandalism, theft and cable ruptures

The risk of vandalism should be addressed in any operation that involves launching fiber optic cables. Vandalism is often carried out by youths trying to provoke a blackout in the system. But blackouts are rare, given the CDCs redundancy, which ensures that the system remains operational. In some areas, the vandals destroy or steal the copper or aluminum cables.

Fiber optic cables do not contain any valuable metals but thieves are unaware of this



Figure 2. Fortaleza Gigafor GPON Network

and rip out cables in hopes of finding copper. When the CDC was first launched, there were monthly cable ruptures caused by thieves. ETICE addressed this problem by leaving small pieces of fiber optic cable attached to poles at a height of 2 meters for potential thieves to inspect. Once they realized the cable did not contain any metal, there was a significant reduction of cable breaks. Today, there is less than one cable rupture per year attributed to theft². Nowadays, the highest frequency of cable ruptures occurs where cables cross highways, primarily because of overloaded trucks.

Service Level Agreements (SLAs) for outsourced managed services

All SLAs for CDC maintenance are based on the quantity of users and redundancy. The goal is to provide acceptable response times for repairs, usually 12 hours at most. All outsourced services are controlled through the ETICE call center, and supervised locally by members of the ETICE engineering team, who reside in five different cities across the state. Fines for service providers are heavy, and are deducted from the monthly payments to the firms.

Two types of contracts are used for the maintenance of fiber optic cables: (a) fixed monthly fee for preventive maintenance and to address emergency situations, and (b) variable remuneration contracts for operations that involve rerouting cables for long stretches or launching new cable. The DWDM network is monitored in Campinas (state of São Paulo) and maintenance service is provided locally. For the network switches that have a lifetime warranty, ETICE relies on spare equipment for immediate replacement. It should be noted that, considering the size of the network, the incidence of problems with switches

²The highest frequency of ruptures occurs where cables cross highways. Statistics show that there are 19 breaks per year caused by trucks carrying cargo stacked higher than the permitted by the transit code (Figure 3). Brush fires account for another 2-3 cable ruptures per year.



Figure 3. Overloaded Trucks Can Cause Cable Breaks

is minimal.

Overheating of electronic equipment

ETICE has avoided the use of air conditioning units, which represent a potential point of failure in the equipment stations. To address potential heating problems, ETICE designed equipment closets with forced air ventilation, without air conditioning, but with the ability to cool an electrical load of up to 1,500 Watts. The overheating problems, which were chronic at the beginning of the project during the hottest season of the year, were eliminated with this new technology at a cost of US\$220,000.

The next section will discuss the current phase of the CDC expansion, and the plans to lease the excess network capacity to private sector operators.

Challenges for the Implementation of the CDC concession/PPP

This section discusses the challenges in implementing CDC concession/PPP model. It discusses the consultations with potential private sector partners and the adjustments that were made to the concessions document to promote greater participation of the private sector, while maintaining the State of Ceará's dual objectives of ensuring the financial sustainability of the CDC and expanding broadband coverage in the state.

First round of the edital

Prior to issuing the initial concessions document, ETICE carried out an initial round of consultations with various potential private sector partners, including large telecom oper-

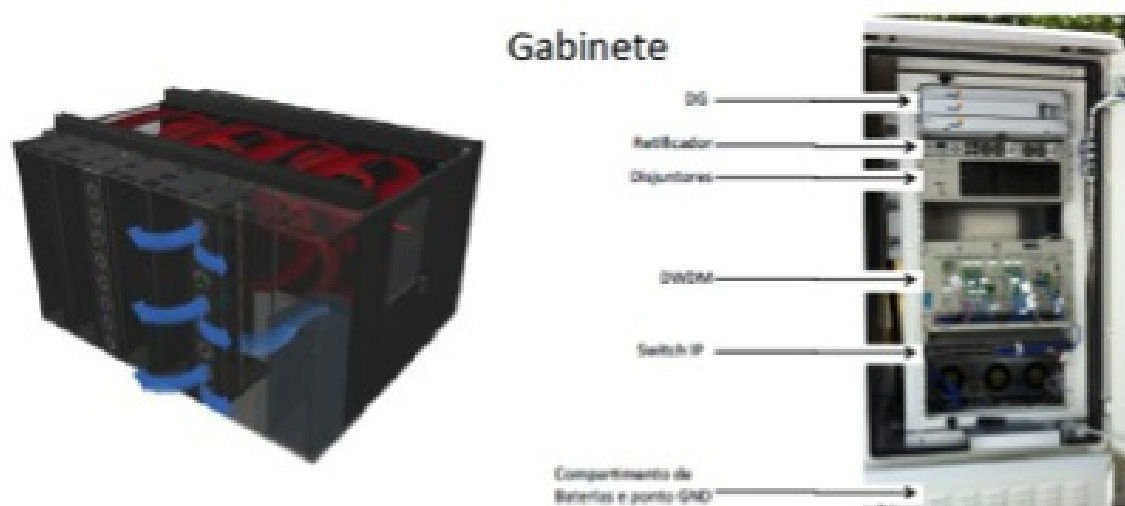


Figure 4. ETICE-designed Forced Air Cooling Equipment Closets

ators and smaller Internet Service Providers (ISPs). ETICE issued the concession document in February 2013. The initial edital offered 15-year concessions for dark fiber in the CDC (subject to a 15 year-renewal). The offer was divided into three lots or fiber, including use of the optical ring, linear extensions of the network, and last mile in cities and towns. Table 1, further below, summarizes and compares the terms of the original edital with the revised edital.

The initial tender was published in April 2013. Despite the interest expressed by potential private sector partners, no formal bids were submitted. Subsequently, both larger telcos and ISPs approached ETICE with informal proposals to establish a partnership to use and maintain the CDC network.

USTDA support and consultation with potential private sector partners

In 2013, the U.S. Trade and Development Agency (USTDA) provided funding for ETICE to engage a team of consultants to assist in revising the initial RFP (edital). The goal of the USTDA-funded technical assistance project (entitled Ceará State Digital Backbone Network Business and Governance Model) was to refine the business model and concession document for the second phase of the CDC to attract private sector bidders and promote participation in the next auction. The U.S. based company Developing Markets Group (DMG) was selected to collaborate with ETICE, and formed a multidisciplinary team of economists, engineers, public policy specialists, and legal advisors to address the needs of the project ³.

The project involved analyzing the initial tender documentation, and discussing ways to restructure the terms based on international best practices, as well as an understanding

³The consultant team included three of the authors of this paper, Glenn Woroch, Flavio Feferman, and Peter Knight.

of the context in Ceará. An important step was to interview stakeholders from the private sector in the state to understand their interests and the factors that led them not to participate in the initial bidding. The team interviewed several companies in the state ICT sector, including:

- Large telecom operators (cell phone, Internet, cable, and land line).
- Small and mid-sized regional ISPs. Many of these ISPs have been trail-blazers in the state, investing in their own networks, including fiber. These ISPs provide a range of services including rural telecommunications, fiber to home, wireless data, and IP media distribution.
- Regional IT companies and industry associations.
- Submarine cable operators.

The interviews proved extremely valuable. First, they confirmed that mid-sized ISPs in the state have developed significant telecom capabilities, already serve many markets in the interior of the state, and have a keen interest in leveraging the CDC network to improve and expand their services (including reselling bandwidth to smaller ISPs). Using the CDC would allow the ISPs to avoid payments to larger operators that currently provide access to many areas of the state (the ISPs can use these savings to lease greater capacity from the CDC). The ISPs understand the consumer markets in small towns and rural areas, and see these markets as attractive business opportunities, with recent growth driven by rising incomes and the Bolsa Família federal cash transfer program⁴. Hence, these ISPs are an important group of potential private sector partners – partners that would share the same objective as the government of Ceará: expanding broadband connectivity in the interior of the state.

Furthermore, these ISPs have begun collaborating more closely with one another, sometimes sharing their infrastructure. Some ISPs have formed a group to jointly bid on the updated concession edital (RFP) that was developed based on the research conducted by the consultants. Therefore the edital needed to be restructured to promote the participation of the ISPs, as will be further elaborated below.

Second, the interviews confirmed the interest of the larger telecom operators in using the CDC network. While these larger operators have developed their own networks in the state, these networks do not provide sufficient coverage or redundancy in certain areas, particularly in the Western region of the state and to some extent in the Northeast region. Operators also noted that the CDC could be used to provide backhaul for cellular phone networks. One operator observed that it pays other telecom companies to utilize their broadband infrastructure, and would prefer avoid this dependency and expand its own network, leveraging the CDC to reduce costs. Larger operators reaffirmed that the interior of the state provides attractive business opportunities, with consumers increasingly using applications that require high bandwidth, such as video streaming and IP TV. In many areas, cellular data is currently used but, in the words of one operator, at the moment fixed Internet arrives, consumers will abandon mobile Internet.

The value of the CDC network was evident across these interviews with potential private sector partners.

⁴Bolsa Família is an important social welfare program in Brazil. It provides cash transfers to lower income families, conditional on the families maintaining their children in school and with their vaccinations up to date.

Given this interest in the CDC, what were the main obstacles to the participation of the private sector? The interviews validated some of the hypotheses held by the ET-ICE/DMG team but also provided some new insights and guidance on reformulating the RFP document. The following themes and issues were emphasized in the conversations with private sector companies, and are likely relevant for similar public-private partnerships for broadband expansion in other regions.

- Upfront payments: The size of the up-front payments in the initial RFP was seen as a major impediment, by both larger operators and especially by smaller ISPs. Companies noted that they would prefer to use the funds to expand their own networks, or would prefer to carry out fiber swaps/payments with other operators to expand the reach of their networks. Operators also mentioned that additional investments in equipment would be necessary to light the CDC dark fiber, further increasing the initial capital requirements. The emphasis on upfront payments in the original RFP was therefore a deterrent, especially for the smaller ISPs (who are in many ways ideal partners).

- Financing for up-front payments and investments: Although financing is available from public and private sources in Brazil, two issues were emphasized: smaller companies often have higher financing costs in Brazil, particularly as they find it harder to access low cost loans from the Brazilian national development bank (BNDES). And second, many of the ISPs have already made significant investments in their networks (or will need to make future investments in equipment to light the CDC dark fiber), therefore these companies cannot take on additional debt to fund the up-front payments, which would require collateral. In the words of one ISP, everybody is already fully invested.

- Buildout requirements: The original RFP included specific requirements for network buildouts of 50 kilometers per year. These were seen as onerous by some prospective builders, who would prefer to expand their networks based on their own business planning and market opportunities (often, investments are carried out in cycles and can well exceed 50 kilometers per year). Would the ISPs obtain a credit for building more than 50 kilometers in any given year? The buildout requirement would also mean that ETICE would need to supervise the private partners to ensure that the buildouts were undertaken, and there would be no assurance that these buildouts would expand the network to priority areas for the state government.

- Reversibility and property rights: The initial RFP required that private investments to expand the CDC network be reverted to the State of Ceará at the end of the concession period. This reversibility of investments was seen as a major impediment by both smaller and larger operators, who wished to maintain the property rights over these network expansions. The reversibility requirement in the initial RFP would not provide incentives for private partners to build the best possible network.

- Network maintenance and management: Some of the companies criticized the maintenance approach in the original RFP, which called for lessees to share the responsibility of maintaining the CDC. This shared approach could lead to coordination challenges, potential free-rider problems, unforeseen costs and risks. One operator suggested the use of a single maintenance contract (a strategy that was ultimately adopted by ETICE). Other companies also mentioned the perceived high cost of the monthly network management fee (R\$205,000 per month) included in the initial RFP.

- Provision of basic Internet access: The initial RFP included the requirement to

provide low cost basic Internet access at R\$29 per month. Operators had mixed views on this requirement. One operator noted that this requirement would reduce flexibility to run his business. Others operators noted that they already offer the basic plan, but that most customers prefer more expensive plans that provide higher connection speeds and greater data usage. However one ISP emphasized that many of his customers can still only afford low cost plans, which he will continue to offer.

- Political risk: Some of the companies interviewed mentioned the risks of changes in government. One company noted that, despite the guarantee of a 15-year contract, a new government with different priorities could neglect certain parts of the network. However, it is important to note that the objective of the public-private business model is to ensure the financial sustainability of the CDC in the long run, thereby reducing these political risks.

In summary, the interviews indicated that the CDC can provide significant value to private sector partners in Ceará, who are keen to expand their services in the state, but the high up-front costs and complex requirements of the initial RFP deterred their participation.

Revised edital

Based on the analysis and consultations with the private sector, the ETICE/DMG team reformulated the RFP document. The revised edital reduces the burden on successful concessionaires with the goal of stimulating interest in participation. Changes include transforming up-front fees into monthly payments (to eliminate financing requirements), no network management fee, shared maintenance costs (and maintenance is outsourced under a separate contract), less onerous buildout requirements and reversion terms, no universal service obligation, and access to COELCE rights of way (through the existing agreement between ETICE and COELCE). To promote competition, more fiber pairs (10 instead of 8) and more lots (4 instead of 3) were assigned for concession, and no company or consortium can bid on more than one lot. Some of the lots were structured to be attractive to smaller ISPs.

One important principle is to rely on market-based incentives: the new RFP allows operators more flexibility to plan their own investments based on market opportunities in the interior of the state (where they are already investing) and removes the reversibility requirement to ensure that operators retain property rights for privately financed network expansions. ETICE will carry out subsequent public investments in areas that remain uncovered, and will gain access to 2 pairs of fibers in all privately built network extensions. The RFP continues to promote widespread access to broadband, while fostering broadband service competition. Table 1 outlines the specific changes made to the edital.

Thus, in the latest phase of CDC development, the state government is working to promote competition by offering excess dark fibers to telecom companies and ISPs, through an Indefeasible Right of Use (IRU) contract for 30 years. Again, ten dark fibers are put up for bid in 4 lots of fiber pairs. The lot winners will be the companies or consortia offering the highest monthly rental value. No concessionaire may win more than one lot. Telecoms carriers may propose joint bids with any kind of company. While ETICE will be responsible for maintaining the cable, concessionaires must light the fibers with their own equipment and maintain this equipment. The four winners will make monthly payments to cover Opex of the network, guaranteeing its long term sustainability under this PPP. The process has been structured to increase competition in the interior of the state.

Table 1:: Summary of key terms and modifications: original and revised edital

	Original Edital/RFP	Revised Edital
Duration	15 years for initial lease with the possibility of second 15-year term.	Same as original Edital
Bidding lots	8 dark fibers offered in 3 lots: Lot 1: 2 pairs + extensions/last mile Lot 2: 1 pair + extensions/last mile Lot 3: 1 pair + last mile only	To promote greater participation, increased to 10 fibers in 4 lots: Lot 1: 2 pairs + extensions/last mile Lot 2: 1 pair + extensions/last mile Lot 3: 1 pair + extensions/last mile* Lot 4: 1 pair + extensions/last mile* partial last mile (Lot 1 is attractive for large telecom companies, other lots provide sufficient capacity for smaller ISPs.)
Min. paymts	Fixed up-front payments: Lot 1: R\$ 17.8 million Lot 2: R\$ 16.7 million Lot 3: R\$ 8.2 million	Reduced and converted to monthly payments to promote participation and eliminate financing needs: Lot 1: R\$ 258,500 per month Lot 2: R\$ 144,600 per month Lot 3: R\$ 140,100 per month Lot 4: R\$ 140,100 per month There is a 4 month advance payment ("luvas") at the start of the project, and payments are annually adjusted for inflation.
Net. mnagmt	Each concessionaire of each lot pays R\$ 205,000/month for overhead management adjusted yearly according to the IGP-M	Eliminated
Net. maint.	Each concessionaire supplies own maintenance	ETICE issued a separate, unified maintenance contract. Concessionaires will pay a single maintenance fee for the CDC backbone, in proportion to the number of pairs leased, at R\$88,000 month/pair. Concessionaires are responsible for the maintenance of their own equipment & network expansions.

Table 1:: Continued ...

Prop. rights	Concessionaire returns facility to CDC at end of contract (15 or 30 years) including the facilities built to meet the build out requirements, even fiber beyond the 50 km minimum. Buildout requirement is for each concessionaire, not proportional to dark capacity purchased.	Dark fibers on existing CDC net. returned to ETICE at the end of contract but bidder keeps any additional fiber and electronics they added. ETICE retains 2 pairs of fibers from private network expansion. This clause ensures that the public sector shares the benefits of privately funded network expansion.
Buildout req.	Build a minimum of 50 km of one (or more) fibers each year in any location in Ceará	Minimum buildout of 50 km per year replaced with a more flexible requirement: during the first five years of the contract each operator must connect the CDC to 10 new municipalities, to be chosen by the operator from a list of 84 cities that do not currently have coverage. The concessionaires will build out based on expected profitability. All expansions by concessionaires must allocate 2 pairs for CDC.
Oblig.& price	Offer R\$ 29/month basic Internet access in all areas (i.e., 1 Mbps for R\$ 29/month with 20% guarantee and a 2 Gb/month cap).	No minimum (universal) retail service obligation on concessionaire. Concessionaire can use capacity for retail, wholesale (reselling to other providers), or for business services.
ROW benefits	No provisions/benefits.	Proposed: Right to utilize electric company (COELCE) poles and accesses in exchange for 2 pairs of fiber for COELCE. This extends ETICEs agreement with COELCE to benefit the concessionaires.

The restructured RFP significantly reduces the requirements for private sector operators, providing more incentives for participation. At the same time, the terms of reference support ETICEs goals of financial sustainability for the CDC and promoting universal broadband coverage in Ceará. The expansion of broadband coverage will happen in four ways:

- Private investments for network expansion based on business opportunities;
- A modest requirement for operators to offer access to 10 new towns and cities, to be chosen by the operators from a list of 84 towns and cities;
- ETICEs rights to 2 pairs of fiber in network expansions carried out by private partners; and
- Subsequent public investments to expand the network to areas that remain uncovered (these new investments are facilitated by the stream of payments from the CDC leasing).

Timetable for Revised Edital

ETICE incorporated the changes recommended by the DMG team, which focused on the specific requirements that had discouraged initial participation by private sector partners. Legal approval from the State of Ceará was obtained at the end of 2014, and the new round of concession bidding is expected to take place in 2015.

Analysis and lessons learned from the bidding process

As ETICE eventually learned, a strategy of Build it, and they will come does not work. The ultimate success of a tender of infrastructure capacity, as was undertaken by ETICE, depends critically on whether credible bidders find it in their own interest to participate. Many factors affect the decisions of potential bidders to participate in the auction. Rational bidders will look beyond the commercial value of the transmission capacity and the outlays needed to win that capacity in the tender; they will make a complete life-of-project assessment of the benefits and costs.

Bidders incur entry costs to participate in the auction quite apart from their cash outlay to acquire the dark fibers. For instance, successful bidders are required to supply their own opto-electronics to light the fibers, and to build or lease space to house that equipment. The successful concessionaire must construct additional pairs of fibers that revert back to ETICE at the end of the contract.

ETICE does not impose an entry fee on bidders for the right to place a bid – a characteristic of some tenders – but bidders nevertheless incur expenses in order to submit bids regardless of whether they win the auction. A bidder must undertake a technical evaluation of the CDC network and its value relative to the bidders current assets, along with estimation of associated operating and maintenance costs and the downstream demand for its data services. Those expenses are sunk if the bidder fails to win a concession.

All of these costs tend to discourage participation in the tender, and may also skew the characteristics of the final bidders. As the auctioneer, ETICE prefers intense competition for the leases so as to generate greater proceeds from the tender, all else equal. It faces as tradeoff, however, when structuring the tender. Participation from some potential bidders can drive others away.

One means to manage the pool of bidders is to pre-qualify candidates before the bidding begins. A typical requirement is to verify the financial solvency of the bidders. The private and social costs of a post-tender default can be huge. Also, potential bidders who otherwise would bid aggressively will be more reluctant to participate if prices are driven up by rivals that are incapable of making good on their bids. The CDC tender has been designed to enable installment financing of the winning bid so as to reduce chances of default, and yet to maintain a large pool of contenders.

Several devices have been incorporated into auction rules in an attempt to balance incentives to participate and to bid aggressively. One tactic is to create a set-aside for a class of bidders who might otherwise conclude the tender is not worth their while. ETICE uses one broad set-aside in its tenders, in that only domestic entities can bid on a concession. There may be many reasons for this restriction, e.g., national security issues, but one consequence is that global communications companies with deep financial pockets are excluded (though their Brazilian subsidiaries can participate). Additionally, ETICE effectively introduces a set-aside when it expends effort to recruit small ISPs for the tender, relative to the large national ISPs. By shielding them from the strong bidders, set asides encourage weaker bidders to participate, but they also reduce the capacity available to the others. The resulting scarcity may have the effect of driving up bids among the strong bidders.

ETICE pursued an indirect approach to set-asides when it structured its fiber offerings to differentially appeal to small and large ISPs. For instance, the smaller lots with a single pair of fibers appeal to the small ISP but not the large ISP. Effectively this strategy is similar to a firm that engages in product differentiation to implement price discrimination. By offering products that appeal to strong and weak bidders differentially, the competition that strong bidders pose for weak bidders is reduced.

One other auction tactic akin to a set-aside which also impacts participation is caps imposed on winnings. The CDCs Terms of Reference limited a concessionaire to just one of the three or four tranches of dark fiber. The bids for the tranches are to be unsealed in sequence, and the winner of the tranche then has its bids removed from consideration for all subsequent tranches. As a consequence, a weaker bidder will see an opportunity to win some tranche where it would otherwise be excluded by a particularly strong bidder absent this rule. In fact, the motivation for this rule is more likely to counter industry concentration than to drive up bidding for the dark fiber.

Another way to encourage auction participation is to assign bidding credit to a select group of bidders. A favored bidder would then pay only a fraction of their bid if they were to submit the highest bid. In that event, the authority receives less than the full amount, but it can happen that the additional competition from favored bidders will cause non-favored bidders to bid higher in the event that the latter wins the auction. ETICE did not extend bidding credits to any bidder group in its tenders, perhaps not seeing that the foregone revenue would pay dividends in terms of higher winning bids.

ETICE expressly encouraged potential bidders to form consortia to bid at the tender⁵. The consequence of this strategy is not obvious. It is possible that some bidders who would not otherwise participate, would do so however as a member of a consortium. In this way a collection of small, weak bidders could combine to pose significant competition for individual

⁵The initial Terms of Reference required that one member of the consortium have a 50% interest or more.

strong bidders. Alternatively, some other bidders might have participated alone but for the option of joining a consortium. It is not clear how these opposing tendencies will balance out.

A common feature of many public auctions is the use of minimum bids. ETICE did set minimum bids for each tranche of dark fiber (i.e., the minimum up-front payments in the initial tender and the minimum monthly lease payments in the second tender). A minimum bid guards against the possibility that bidders out for a bargain will snap up the fiber far below market value; it also helps the seller defend against the collusive pricing of a bidding ring. If the minimum bid is set too high, however, participation can be greatly curtailed. There is evidence that the minimum bids published in the initial Terms of Reference suffered from this problem, and were at least partly responsible for its failure.

Innovations on the conventional auction formats have been observed that likely stimulate interest among potential participants and also intensify competition in subsequent bidding. See (Klemperer, 2002) on Anglo-Dutch auctions, and also (Milgrom, 2004) on premium auctions. The so-called premium auction offers the second-highest bidder a share of the difference in its bid and the winning bid. As a result, a bidder can walk away with some amount even if it loses the bidding. This prospect will encourage it to participate and possibly to bid more aggressively as well. These features did not appear in the current CDC Terms of Reference but may have benefits for subsequent auctions.

Lessons Learned

We identified several successes that ETICE achieved during the CDC project, if sometimes by trial and error. One important lesson produced a number of tactics to promote participation in the concession bidding for dark fiber. In this section, we collect together the various lessons we extract from the experience of ETICEs public-private business model for implementing the CDC.

1. Leveraging partnerships and the strengths of each partner:

The CDC business model bridges the gap between purely public and purely private ownership, leveraging the strengths of partners in the public, private, and academic sectors. The initial CDC deployment benefited from its collaboration with the state electrical utility which provided access to its rights-of-way and utility poles. The academic community was also a key partner during the CDCs proof of concept phase. In the current phase, private sector telecoms and ISPs bring a range of capabilities to the public-private model including rapid deployment of digital services, marketing reach, innovation, and attractive pricing. ETICE understands that its core business is managing the fiber backbone infrastructure while delegating data transport services, network maintenance and last-mile distribution to private sector partners. By including many private sector participants, ETICE pursues its goals of broad network coverage and redundancy while at the same time promoting low prices and innovative services.

For its part, the state government makes three important contributions to the CDC: (a) the initial investment in the network infrastructure, (b) the management of the shared backbone infrastructure, and (c) the coordination of the different actors in the CDC ecosystem. The public investment in the infrastructure has several advantages. It takes advantage of the public sectors lower cost of capital, relieving all carriers (especially the smaller ISPs) of the Capex burden. It allows ETICE to use a simpler auctions/concession PPP, rather than

the more complex Brazilian PPP Law 11,079. That arrangement is tailored to the usual build-operate-transfer scenario and requires reversibility of new investments at the end of the project – a major obstacle for participation of private sector operators in the initial concession bidding.

2. Balancing financial sustainability and social goals:

The CDC balances the requirement for financial sustainability with social goals of providing broadband access to small towns and rural areas of the interior as well as major cities in Ceará. With regard to sustainability, the CDC model is structured to generate the revenues required for operations, avoiding financing dependence, which buffers the CDC from the changing winds of state politics and changing budgetary allocations. As noted earlier, the CDC has lowered the state governments expenses significantly by displacing connectivity contracts with private telcos. ETICE also charges government clients for its services according to a transparent fee schedule. Nevertheless, the State of Ceará struggles with the temptation to provide free broadband services, a policy pursued by many other Brazilian states. The proposition of free Internet for everyone, everywhere, all the time spells financial doom for a project such as this.

The dark fiber concession is another element of the financial sustainability strategy. Through the concession, private operators will contribute significantly to the long-term financial sustainability of the CDC by sharing operational costs. Lower Opex for the government means more investment in the long term, including new investments in the expansion of the CDC.

At the same time, the CDC stays focused on its mission to promote universal broadband access in the state of Ceará. This objective has been incorporated in the current edital by having the CDC share its network with private sector concessionaires, with requirements and incentives for the private expansion of the network. Indeed, the CDC has already made significant contributions to digital inclusion in the state. ETICEs main metric used for its planning decisions – the number of users connected – shows an increase over time. For example, ETICE tracks the number of email addresses issued in connection with the CDC, which has now reached nearly 1.5 million. World Bank analysis reported by ETICE also indicates a broadband coverage rate for urban population in the state of 82% (this coverage was virtually nil prior to the CDC).

3. Promoting competition:

Competition in the telecoms sector is critical to keeping rates for broadband affordable, and lower prices are the best way to increase Internet adoption and use. In a competitive market, scaling up usage drives revenue, and ultimately supports greater investment. The CDC model can help stimulate competition in regions with limited competition by, first of all, offering an alternative network to the private sector carriers. Furthermore, the CDC can promote competition by facilitating the entry and expansion of smaller carriers into the market. In Ceará, the smaller ISPs have been instrumental in reaching customers in the interior of the state. In contrast, larger telcos could use the CDC infrastructure as a means to deliver service other Brazilian states (leveraging Fortalezas strategic position as a landing point for international cables), rather than expanding Internet access in underserved regions of Ceará.

Exporting the CDC model

Above we described the ongoing efforts and challenges in Brazil to reform its telecommunications sector. At the same time, there is an urgent need to expand and modernize ICT infrastructure, to increase productivity, to improve the delivery of public services, and to promote digital inclusion.

Both the private sector and public/academic institutions have been involved in broadband expansion in Brazil, but with limited collaboration between them. On the private sector side, large telcos have expanded access at scale, but there remain issues with broadband coverage, service quality, and cost of service. On the public/academic side, the public/academic broadband networks that have been deployed, most of which were organized by the RNP, did not follow a commercial model that would extend coverage beyond their academic and government users or to provide competition in the telecoms sector. Where local public/academic networks are not available, governments usually rely on expensive contracts with private carriers for their own connectivity requirements.

Many Brazilian states face the same challenges of high-cost broadband deployment and high concentration among regional telecom carriers similar to the state of Ceará. Several Brazilian states are searching for business models involving both public expenditures and private participation to reach underserved regions in a country of continental proportions. Because the laws that regulate telecommunications are federal, the Ceará CDC model can be applied to other states.

States such as Rio de Janeiro, Pará, Paraíba, Rio Grande do Sul, Piauí, Sergipe, Tocantins and Santa Catarina are exploring public-private collaborations inspired, in part, by the CDC experience. The goals of these projects are similar: expand broadband access to underserved areas, connect government agencies to improve the quality of public services, and achieve financial sustainability without relying on state budgetary allocations. ETICE recently received officials from Bahia (Governors office), Minas Gerais (Secretary of Planning), Paraíba (CODATA), and Rio Grande do Sul (PROCERGS) to discuss the CDC experience. During the 2014 FIFA World Cup, Telebras used the CDC infrastructure to fulfill FIFA requirements, further promoting the CDC nationally.

Conditions conducive for the CDC model

The CDC model is most relevant for regions with significant unmet bandwidth demand, urban-rural service gaps, limited competition among carriers, and high prices for Internet access. In these regions, public investments and business models along the lines of the CDC can stimulate competition, lower service costs, and promote access, while covering the state company's operational costs. Studies by the Brazilian Ministry of Telecommunications indicate that reductions in service costs have a significant impact on telecommunications demand. The price elasticity of demand for telecommunications services in Brazil ranges from 1.0 to 3.4, so a 10% reduction in service costs can raise demand by 10% to 34% (Knight, 2014).

The presence of a vibrant community of ISPs can accelerate provision of broadband services. In regions where financing for small and medium enterprises is costly, public investment in the infrastructure becomes especially important. By financing the initial investment, the government can greatly reduce the Capex requirements of private sector

partners that participate in the project under a simpler concessions structure (rather than a PPP under Law 11,079, as noted above). Additionally, the infrastructure can be shared by multiple smaller carriers, as in the case of the CDC⁶.

Major impediments to implementing the CDC model

Where the political influence of the major incumbent telecommunications operators is strong, there can be resistance to the development of state-owned broadband networks, since this tends to reduce the monopoly or oligopoly rents accruing to these firms. National constitutions/laws may also restrict the formation of PPPs. Another impediment to exporting the CDC model is the implementation capacity of the public sector, including the financial, technical, and managerial resources required to undertake a large, complex telecommunications project. For example, many Brazilian states currently struggle with budgetary constraints and may not be able to finance a project like the CDC. Finally, implementing a project such as the CDC requires the capability to coordinate the various actors (public, private, and academic) in the ecosystem, as demonstrated by the CDC case.

Conclusions

The state of Ceará has made rapid progress in meeting its broadband needs by developing an innovative PPP business model to deploy the CDC network. The CDC is considered to be state-of-the-art network, similar in many respects to the best examples of such networks in the United States⁷. The CDC experience also shows that government financing and ownership of broadband infrastructure can facilitate the participation of private companies and, paradoxically, promote private sector competition. Further, a financially sustainable business model can insulate the project from political risks, such as changes in government. Over time, ETICE has adapted its model to respond to market conditions and the concerns of potential participants in its auction of fiber capacity. Other Brazilian states are closely studying the experience of Ceará as they plan to build and expand their own broadband networks.

The CDCs fiber optics infrastructure allows Ceará's public administration to carry out innovative broadband projects, otherwise impossible, such as tele-health, distance learning, video surveillance for public safety, and remote cargo scanning. Further, the CDC promotes greater efficiency in the state administration by expanding access to information technology to all state agencies. The state government is collecting randomized baseline data to determine the impact of broadband access on schools, hospitals, other public safety agencies, and private sector enterprises, among others. These data include a range of socioeconomic indicators such as per capita GDP, national educational exam grades, ambulance traffic among cities, and crime reduction.

The CDCs fiber optics infrastructure allows Ceará's public administration to carry out innovative broadband projects, otherwise impossible, such as tele-health, distance learning,

⁶It should be noted that lending to public sector projects by the World Bank, the Inter-America Development Bank, and the Brazilian National Economic and Social Development Bank (BNDES), is also constrained by state borrowing limits set under the federal Fiscal Responsibility Law.

⁷Conversation with Joanne Hovis, President of CTC Technology and Energy and a keynote speaker at a conference on Community Broadband Networks and Economic Development organized by Broadband Communities magazine, Springfield, MA, 16-18 September 2014.

video surveillance for public safety, and remote cargo scanning. Further, the CDC promotes greater efficiency in the state administration by expanding access to information technology to all state agencies. The state government is collecting randomized baseline data to determine the impact of broadband access on schools, hospitals, other public safety agencies, and private sector enterprises, among others. These data include a range of socioeconomic indicators such as per capita GDP, national educational exam grades, ambulance traffic among cities, and crime reduction.

The CDC model serves as a framework for municipal, state and national governments in Brazil and other countries that face the challenges of expanding broadband access and improving the quality of public services.

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Appendix

PPP background and PPP contracting frameworks in Brazil

Brazilian law provides three main contracting vehicles for infrastructure and services provision between government and private sector companies: standard contracting law (8,666), Concessions Law (8,987), and the Brazilian PPP Law (11,079). Several Brazilian states, including Ceará also have their own PPP laws. For telecommunications concessions involving bidding, Brazilian Auctions Law (10,520/200) is used. Each of these contracting frameworks can be understood as a type of public-private partnership, though the term PPP is generally used for Brazilian PPP Law 11,079 and to some extent for Concessions. In this paper, we use PPPs to refer to these two types of contracting frameworks.

Conventional contracting law (Law 8,666/1993) is the simplest and most commonly used government procurement arrangement, including contracts for ICT services. Law 8,666 stipulates a maximum term of 5 years for the contract duration. The Concession law (Law 8,987/1995) enables the government to assign construction and/or operation rights of a particular infrastructure project to a private sector concessionaire. The concessionaire recovers capital investments and operating costs by charging user fees to the public, often within guidelines set forth by the contract. A road maintenance and toll collection project is a typical example of a concession project.

The third instrument, Brazilian PPP law (Law 11,079/2004), was enacted in 2004 and largely follows the framework pioneered in the United Kingdom during the 1990s, with a few modifications and innovations. In the strict application of Law 11,079, the PPP framework is a service agreement utilizing an alternative finance mechanism that enables the public sector to transfer the construction and operation of a public infrastructure, and the provision of services, to the private sector. PPPs differ from Concessions because the private partner typically carries out significant infrastructure investments and is remunerated at least partially by the government, rather than entirely by the general public. Under the Brazilian PPP law, the assets of the project revert to the government after the contract period. Due to the implementation complexity of PPPs including a time-consuming review by a PPP Council, formation of a Special Purpose Entity (SPE) by the private sector partner(s), and establishment of a guarantee fund by the government, among other procedures the Brazilian experience with strict PPPs has been limited.

The CDCs public-private business model utilizes a concession framework, but through the Brazilian Auctions Law (10,520/2002), which is used in telecommunications concessions involving bidding. This legal framework provides a good fit with the CDC model and objectives.

- The concessions framework, which is a form of public-private partnership, avoids the complexity and time required to establish a strict PPP under Law 11,079 and the corresponding Ceará Law 13,557. The concessions framework is appropriate in this case, given that the CDC infrastructure has already been developed by the government of Ceará, which is now leasing the excess capacity of the network.

- The PPP Law 11,079 would be more appropriate in other cases, where significant new investments are required to establish a network like the CDC. Given that the Government of Ceará was able to finance the network on its own, the concession structure provides simpler framework for a public-private business model.

- Compared to Law 8,666, the concession framework enables the government to establish a longer-term contract (15 years in this case), avoiding the five year limitation under Law 8,666.
- The use of the concessions framework and Brazilian Auctions Law, allows for multiple private sector partners-operators, which promotes competition in the telecoms sector of the state. A strict PPP (Law 11,079) typically involves multiples bidders, but a single PPP contract.
- With multiple, competing operators (lessees of the network), the benefits of improved efficiency and innovation over time are passed on to customers in the form of lower prices. Under a PPP (Law 11,079), the process for sharing efficiency gains is much more complex, requiring contract clauses to rebalance payments.
- Finally, the formal PPP (Law 11,079) framework requires reversibility of the investments by the private sector partners at the end of the contract (including extensions to the network built by these partners)⁸. Our conversations with potential private partners in Ceará revealed that reversibility was an important obstacle to participation in the bidding.

⁸Reversibility means that the concessionaire must return the object of its investment to the concession-granting government at the end of the concession period.